Physics 129 A
Fall 2004
Professor Freedman
November 14, 2004
Problem Set# 8 (Due: November 22, 2004)

1. (Perkins 2.5) Draw Feynman diagrams (in terms of transitions at the quark level if hadrons are involved) for the following weak decays:

$$\pi^+ \to \mu^+ + \nu_\mu$$
$$\Lambda \to p + e^- + \nu_e$$
$$K^0 \to \pi^+ + \pi^-$$
$$\pi^+ \to \pi^0 + e^+ + \nu_e$$

Draw Feynman diagrams for the following strong decays:

$$\omega^0 \to \pi^+ + \pi^- + \pi^0$$
$$\rho^0 \to \pi^+ + \pi^-$$
$$\Delta^{++} \to p + \pi^+$$

2. (Perkins 5.4) In an e^+e^- colliding-beam experiment, the ring radius is 10 m and each beam forms a 10 mA current, with cross-sectional area of 0.1 cm^2. Assuming that the electrons and positrons are bunched and that the two bunches meet head-on twice per revolution, calculate the luminosity in $cm^{-2}\ s^{-1}$ (a luminosity L provides a reaction rate of σL per second for a process of cross-section σ). From the Breit-Wigner formula (Perkins Eq. 2.28) calculate the cross-section for the reaction $e^+e^- \to \pi^+\pi^-\pi^0$ at the peak of the ω resonance, assuming that the branching ratio for $\omega \to e^+e^-$ is simply α^2. Hence deduce the event rate per hour for this process with the above luminosity ($m_\omega c^2 = 783$ MeV, $J_\omega = 1$.)

3. What is the expected ratio of $\sigma(e^+e^- \to \text{hadrons})$ to $\sigma(e^+e^- \to \mu^+\mu^-)$ at 2, 7 and 20 GeV?

4. Assuming two-flavor neutrino mixing, show that the probability for a $\bar{\nu}_e$ of energy E (MeV) to be detected as a $\bar{\nu}_e$ a distance L (km) away from where it is produced is given by:

$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2(2\theta)\sin^2(1.27\Delta m^2 L/E)$$
$$\Delta m^2 = | m_2^2 - m_1^2 |$$